TREATMENT OF WELL WATER USING BIOSORBENT DERIVED FROM ARECA FIBER WASTE

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Abstract: The biosorption of well water using biosorbent from areca fiber waste of Jambi province has been performed to elevate well water quality. In environmental preservation, this research aimed to reduce a solid waste of areca fiber waste, which has only been burned so far. This activity would increase carbon emissions in the atmosphere. These materials were obtained using carbonizations (300 and 400 ^{o}C) and without carbonization. The proper material is used as a biosorbent was 400 ^{o}C sized 200 mesh. The material showed several functional groups on the biosorbent surface, such as hydroxyl, amide, amine, and carbonyl. Interestingly, using this material, the water quality can be increased by treatments of odor, color, pH, TDS, TSS, and E. coli under conditions 1.25 g biosorbent, 50 ^{o}C, and 150 rpm for 30 minutes. The adsorption results were compared with the value from the standard of Permenkes No.146/Menkes/Per/IX/1990. Based on the explanation, it is resumed that biosorbent derived from areca fiber waste is effective, inexpensive, and easy to operate for increasing well water quality.

Keywords: areca fiber waste, biosorbent, well water

Abstrak: Adsorpsi air sumur menggunakan biosorbent dari limbah sabut pinang Provinsi Jambi telah dilakukan untuk meningkatkan kualitas air sumur. Pada pelestarian lingkungan, penelitian ini bertujuan untuk mengurangi limbah padat sabut pinang, yang selama ini hanya dibakar. Kegiatan ini akan meningkatkan emisi karbo ke atmosfir. Material-material ini diperoleh menggunakan karbonisasi (300 dan 400 ^{o}C) dan tanpa karbonisasi. Material yang tepat digunakan sebagai biosorben adalah 400 ^{o}C berukuran 200 mesh. Material ini memperlihatkan beberapa gugus fungsi pada permukaan biosorben, seperti hidroksil, amida, amina, dan karbonil. Menariknya, penggunaan material ini, kualitas air dapat ditingkatkan menggunakan treament aroma, warna, pH, TDS, TSS, dan *E.Coli* pada kondisi 1,25 gram biosorben, 50 ^{o}C, 150 rpm, dan selama 30 menit. Hasil adsorpsi dibandingkan dengan nilai standar Permenkes No.146/Menkes/Per/IX/1996. Berdasarkan penjelasan, hal ini disimpulkan bahwa biosorben dari limbah sabut pinang efektif, dan mudah untuk menggunakan untuk meningkatkan kualitas air sumur.

Kata kunci: air sumur, biosorben, limbah sabut pinang

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Introduction

Water pollutant is becoming a harmful problem because it reduces water quality for living things (Singh et al., 2018). The contaminated water could not support life, so treatment is needed for increasing water quality. Based on United Nations Water (UIN-Water) data and statistics, the world's requisite clean water for the next 40 years will increase by 19%, including for irrigation and agriculture (Wong et al., 2018). Currently, contaminated water is a critical matter on earth; many as 2.2 billion people have difficulty accessing clean water (UN Water, 2021). Therefore, many researchers and governments are trying to find an advanced technique (Wong et al., 2018). There are methods for purifying contaminated aqueous such as filtration, precipitation, electrochemical, membrane, solvent extraction, ion exchange, microbes, and adsorption. The previous study recommended adsorption using biomass to reduce water pollutants because it has advantages such as inexpensive, available, environmentally friendly, and efficient (Wong et al., 2018).

One of the potential biomass is areca fiber waste, a by-product from areca seed treatment. A previous study explained that activated charcoal derived from the heartwood of areca could absorb heavy metals of lead(II). In that study, the functional groups led to binding heavy metals such as hydroxyl, carbonyl, amide, and amine (Chakravarty et al., 2010b). Furthermore, areca waste also absorbs cadmium and copper at a pH of 5.6 (Zheng et al., 2008). Cu(II), Pb(II) (Chakravarty et al., 2010a; Tiwari et al., 2015). The performance of this biosorbent was tested on adsorption of Brilliant Dye (BG), a dye for industrial purposes, namely paper, wool, cotton, leather, etc. The adsorption of BG occurred on maximum pH of 7 (Sukla Baidya & Kumar, 2021).

Organic waste as a raw material for biosorbent production is a solution to reduce solid waste. Jambi province is one of the largest exporters of areca in Indonesia, has not yet to carry out post-treatment processing of areca. The primary goal in areca treatment is to obtain the seed to remain areca fiber as solid waste to the environment (Wong et al., 2018). This solid waste is just thrown and burned, adding carbon emissions to the atmosphere (Gogoi et al., 2017). This waste's cellulose and lignin contents make this waste appropriate to be used as a biosorbent using the carbonization process. Based on the explanation, this research was conducted to obtain biosorbent from areca fiber waste for purifying well water. Well, water quality before and after adsorption Well water quality before and after adsorption would be observed and characterized comprehensively based on several parameters: odor, temperature, color, Total Dissolved Solid (TDS), pH, Total Suspended Solid (TSS), Pb, turbidity, and *E-Coli* bacteria.

Experimental Method

Biosorbent preparation

Areca fiber waste was obtained from Tanjung Jabung Timur regency, Jambi province. This waste is a residue from the treatment of seed Areca in that area. The Areca fiber waste was washed using fluent water to eliminate inorganic impurities. This waste was dried under the sun for seven days to evaporate water vapor content. The drying process was continued using the oven at 105 ^{o}C for 1 hour to omit the remaining water content on the material. The Areca fiber waste was crushed using a blender machine before calcination. The material was activated in two ways, such as carbonization and without carbonization. The carbonizations were conducted at 300 and 400 ^{o}C for 1 hour. Three biosorbents were yielded, such as 400 ^{o}C (A), 300 ^{o}C (B), and without carbonization (C). The biosorbents were sifted using a 200 mesh sieve and stored in the desiccator to keep their quality (Utami, 2019).

Biosorbent characterization

The powdered biosorbent was characterized to explore the performance of the porous material as a biosorbent. This characterization is a critical key in material design for better application. The biosorbent performance was characterized by ash and water contents, and the results were compared with the Standard Nasional Indonesia (SNI) 06-3730-1995. These materials' functional groups were analyzed using Fourier transform infrared (FTIR) (Tiwari et al., 2015).

Adsorption batch of well water

We selected the proper biosorbent based on preliminary observations from 300 ^{o}C, 400 ^{o}C, and without carbonization. 1.25 grams of areca fiber waste was poured into 100 mL well water in a 1000 mL Erlenmeyer flask for 30 minutes. This activity was stirred at 150 rpm at 50 ^{o}C (Burakov et al., 2018; Wong et al., 2018).

Characterization of well water

The well water has a low quality due to pollutants from human activities in a modern lifestyle. Therefore, the researcher collected well water near State Islamic University Sulthan Thaha Saifuddin Jambi. The sample area was listed in Figure 1. Based on Figure 1, we could observe the sampling location near the swamp. Therefore, the researcher decided to treat this water using a biosorbent from areca fiber waste. The well water was measured before and after adsorption with several characterizations based on Permenkes No. 146/Menkes/Per/IX/1990, namely odor, color, temperature, pH, TDS, TSS, Pb, and *E. coli* (Sivakumar et al., 2014).

Figure 1. The sample area of this research, (a) swamp around the well, (b), (c), and (d) the well water condition with a rusty cover.

Result and Discussions

Biosorbent characterizations

The washing of an areca fiber waste was for eliminating the inorganic impurities, sand, and sludge. The samples were divided into several categories (Table 1). Before the biomass was calcined at a specific temperature, we collected and sun-dried procedure to reduce water content for seven days (Chakravarty et al., 2010a; Gogoi et al., 2017). The biosorbent preparation is depicted in Figure 2. The ash content analysis in Table 1 shows that sample C complies with the standard of SNI No. 06-3730-1995. Based on that standard, the best charcoal has an ash content maximum of 10%. Ash is the remaining residue of the biosorbent carbonization process.

The appropriate ash content based on standards indicates that the materials have good quality. Otherwise, the higher ash content causes decreasing material mechanic strength to degrade absorption capacity (Okolo et al., 2020). The A and B samples have an ash content more elevated than the standard. The increase of the ash content in the material due to oxidation processes at high temperatures. Other than that, we performed a water content analysis. We can see in Table 1; sample A has the lowest water content of 23.06%. The maximum water content based on the SNI No. 06-3730-1995 is 15, and all samples do not conform to that standard. It is caused by water contamination during retention. Furthermore, temperature and dampness of storage influence water content increasing in the material. Besides ash and water contents, biosorbent performance is supported by the functional group's presence in the biosorbent surface (Jobby et al., 2018).

(a) (b) (c) (d)

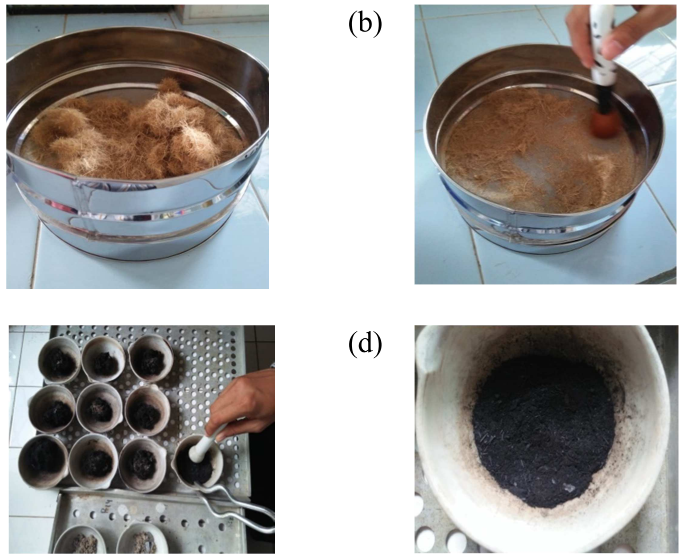

Figure 2. The biosorbent making, (a), (b) without carbonization and (c), (d) using carbonization

Table 1. Characterization of biosorbent from areca fiber waste

Temperture (°C)	Time (hour)	Code	Ash Content (%)	Water Content (%)
400	1	A	27.02	23.06
300	1	B	43.99	24.74
Without carbonization		C	2.45	26.48

The impurities removal from well water using biosorbent is based on the active functional group on that surface material. The functional groups in biosorbent have an affinity for trapping impurities in the active site. These functional groups found in biosorbent are carbonyl, amine, hydroxyl, amide, and metal (Chakravarty et al., 2010b). Moreover, carboxyl, phenol, lactone, and quinone are also established in biosorbent, bound in the edge of graphite-like (Burakov et al., 2018; Deliyanni et al., 2015). The wavenumber and spectra from biosorbent characterization are presented in Table 2 and Figure 3.

Table 2. The functional group of biosorbents from areca fiber waste using FTIR

A (cm^{-1})	B (cm^{-1})	C (cm^{-1})	Description
1500		1599.06	Amine
1735			CO (aldehydes)
1850			CO (acyl halides)

A (cm^{-1})	B (cm^{-1})	C (cm^{-1})	Description
	2112.14		CO (ester)
	2664.14		SH (sulfur)
3145.39			NH (amide)
		3173.04	NH (amide)
	3216.44		NH (amide)
3500-3600	3500-3600	3580-3600	OH (hydroxyl)

Based on Table 2, sample A has five peaks that specify a specific functional group. Peaks of 1500, 1735, and 1850 cm^{-1} represent amine and CO (aldehydes and acyl halides), respectively (Sukla Baidya & Kumar, 2021). The study's result is similar to previous research, which states that the area indicated C=O stretching and CO chelate stretching (Chakravarty et al., 2010a). The peak of 3145.39 cm^{-1} illustrates NH (amide). Simultaneously, the peak of 3660-3500 cm^{-1} represents OH (alcohol), and this peak is the sharpest than samples B and C (Chakravarty et al., 2010b).

For sample B, there are several dominant peaks such as 2112.14 cm^{-1} for CO (ester), 2664.14 cm^{-1} for SH (sulfur), and 3216.44 cm^{-1} for NH (amide), respectively. In Fig. 3, sample B shows a stretching vibration from OH (alcohol), but the peak is sloping in the 3600-3500 cm^{-1} area. This study's results are similar to previous studies, which resulted in dropping OH stretching (Bhattacharjee et al., 2020). Next, there are peaks in sample C, namely 1599.06 cm^{-1} for CO and 3173.04 cm^{-1} for NH. This material also shows an OH spectrum in 3600-3580 cm^{-1} area. Based on the explanation about ash and water contents and functional groups analysis, the researchers conclude that sample A is a potential material for adsorbing well water to increase the quality.

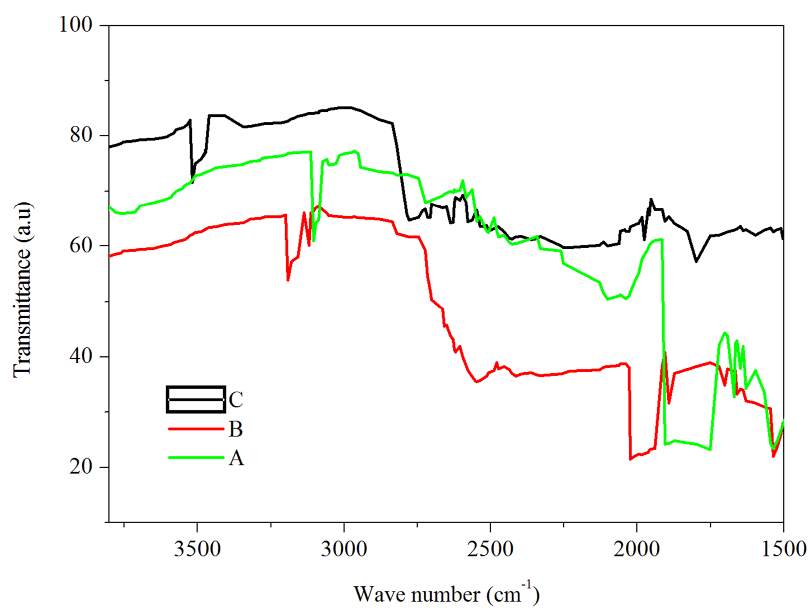

Figure 3. FTIR of biosorbent derived from areca fiber waste

Adsorption of well water using biosorbent from areca fiber waste

The adsorption method using biosorbent is promising because it has advantages, such as high specific area, high porous, presence of functional groups, and volume micro (Burakov et al., 2018; Kang et al., 2008). The measurements of well water adsorption using sample A are listed in Table 3. Table 3 shows that there are nine parameters tested before and after adsorption. In addition, color and odor parameters were conducted using the organoleptic test. Before adsorption, the well water has been visibly smelly and muddy. These conditions are caused by the presence of dissolved organic matter in water. The organic compound is originated from decaying organic matter, various microorganisms, and other chemical compounds such as H_2S.

Moreover, the location of the well is near the swamp, so the water of the swamp sink and contaminates the well water. Previous studies claimed that muddy and smell in water were also caused by leachate from rainwater passing through the garbage pile. This leachate contains various organic materials, even heavy metals (Wong et al., 2018). After adsorption using this biosorbent, the color of the well water was changed to clearer, and the biosorbent could reduce the nasty smell.

These phenomena happened due to the trapping of organic compounds in the active site of the biosorbent. The difference of color between well water before and after treatment is presented in Figure 4. This research is also supported by a previous study that biosorbent derived from areca fiber waste adsorbed dye compounds (Sukla Baidya & Kumar, 2021). The color change in treatment well water is due to functional groups' presence on the material surface. The impurities would interact with functional groups, namely carbonyl, hydroxyl, carboxyl, and amino. The positive impact of this process is the effect of water purification (Jobby et al., 2018).

Table 3. The quality of well water between before and after adsorption using biosorbent derived from areca fiber waste (400 ^oC)

Parameters	Units	Before	After	Standards*
Odor	-	Nasty odor	Little odor	No odor
Color	-	Muddy	Clearer	No color
Temperature	^oC	27.4	28.1	air temperature ±3
pH	-	5.0	7.0	6-9
TDS	mgL^{-1}	73	21.7	1000
TSS	mgL^{-1}	34	5.6	1000
Pb	mgL^{-1}	<0.03	<0.03	0.05
E.coli	JPT/100	32	11	0

*Permenkes No.146/Menkes/Per/IX/1990

Besides, the temperature and pH are also vital for water quality. Based on Table 3, it can be seen that there was an increase in well water temperature from

27.4 to 28.1 ^{o}C, and this value is fitted with the standard. The Previous research explained that the water temperature changes were also caused by the water movement when it was put into the sample bottle from the sample area to the laboratory (Gusril, 2016). Furthermore, the pH of well water needs to be known because this is an important parameter. The acidic and alkaline water can cause damage to organs and daily life supplies. Adsorption using biosorbent changes pH from acidic (5) to neutral (7). The increasing pH value of well water after treatment using biosorbent was caused by interaction among particle and dissolved compound with functional groups in biosorbent surface (Bhattacharjee et al., 2020). According to Permenkes No. 416/Menkes/PER/IX/1990, regarding the requirements for clean water. This study did not measure the type of particle and solutes, but the previous study explained that waters acidic were due to the arsenic presence (Shah et al., 2020). The acidic is also caused by the existence of fulvic dan humic acids. These compounds are insoluble in water and have a conjugated double bond, and high in aromatic carbon. These compounds were reported to be harmless to human health, but this compound would react with chlorine in chlorination forms a disinfectant (García, 2011).

Figure 4. The color of well water before (left) and after (right) adsorption using a biosorbent derived from areca fiber waste

The other physical properties measured are TDS and TSS. These properties experienced a decrease after adsorption (see Table 3). A previous study described reducing these values because active sites at the biosorbent surface entrapment particles (Sia et al., 2017). The performance of biosorbent is also tested in the removal of Pb in well water. The presence of Pb in water can harm humans and animals. Previous research noted that Pb exposure in water is due to the pulp and paper industry, fuel plant, battery, gun, and waste treatment. This heavy metal has not biodegradable properties, so it needs a method to remove it from water (Chakravarty et al., 2010b). However, the concentration of Pb metal after adsorption did not show any change. This is due to the saturation of the active site of the binding on the biosorbent surface (Chakravarty et al., 2010b).

Next, microbiological properties measured for identification of the quality of well water are *E.coli* content. This contaminant is originated from human and animal feces, which can cause gastrointestinal and diarrhoeal (Abu Hasan et al., 2020; Parker et al., 2010). Surprisingly, the bacteria content in well water is 32 but has decreased by 65.63% after adsorption. 200 mesh sieving caused the size of the material to be smaller so that this process provided sufficient active site to absorb bacterial contaminant in well water. The previous studies explained that the subtraction of bacteria content in the water purified using biochar is due to pores of different sizes on the biosorbent surface (Pongener et al., 2017; Rahman et al., 2020). Therefore, there is a possibility that the surface of these materials has pores that absorb bacteria. This property could be improved by performing a surface morphological analysis. Functional groups on the surface of the material also affected the *E.coli* entrapment process. Based on the explanation, biosorbent derived from areca fiber waste can be developed to be biosorbent for absorbing impurities in well water (Ali, 2012; Pongener et al., 2017).

Conclusion

The well water treatment was performed using biosorbent derived from areca fiber waste, locally available in profusion. The study results, such as odor, color, pH, TDS, TSS, Pb, and E.Coli content, have improved well. In addition, this material is promising for removing impurities in well water. Thus, this research provides insights into several sectors, such as improving water quality and reducing areca fiber waste as a by-product. After characterization of the material, the researchers recommend this material is developed with advanced treatment.

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